US008231781B2

(12) **United States Patent**
Lepine et al.

(10) **Patent No.: US 8,231,781 B2**
(45) **Date of Patent: Jul. 31, 2012**

(54) **FILTER END CAP ASSEMBLY WITH BYPASS VALVE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/272,759**

(22) Filed: **Oct. 13, 2011**

(65) **Prior Publication Data**

US 2012/0031822 A1 Feb. 9, 2012

Related U.S. Application Data

(62) Division of application No. 12/436,525, filed on May 6, 2009, now Pat. No. 8,083,938.

(51) **Int. Cl.**
B01D 27/10 (2006.01)

(52) **U.S. Cl.** **210/130**

(58) **Field of Classification Search** 210/130–133
See application file for complete search history.

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(57) **ABSTRACT**

A filter assembly, filter element and methods are provided. The filter assembly includes a filter base in which a filter element is mounted. The filter element includes a bypass valve carried by the filter element that operates independent of and free of interaction with the filter base. Methods include providing an entirely new bypass valve for the filter assembly by inserting a filter element including a complete bypass valve into the filter base such that bypass valve structures of the filter base are rendered useless or superfluous.

9 Claims, 10 Drawing Sheets

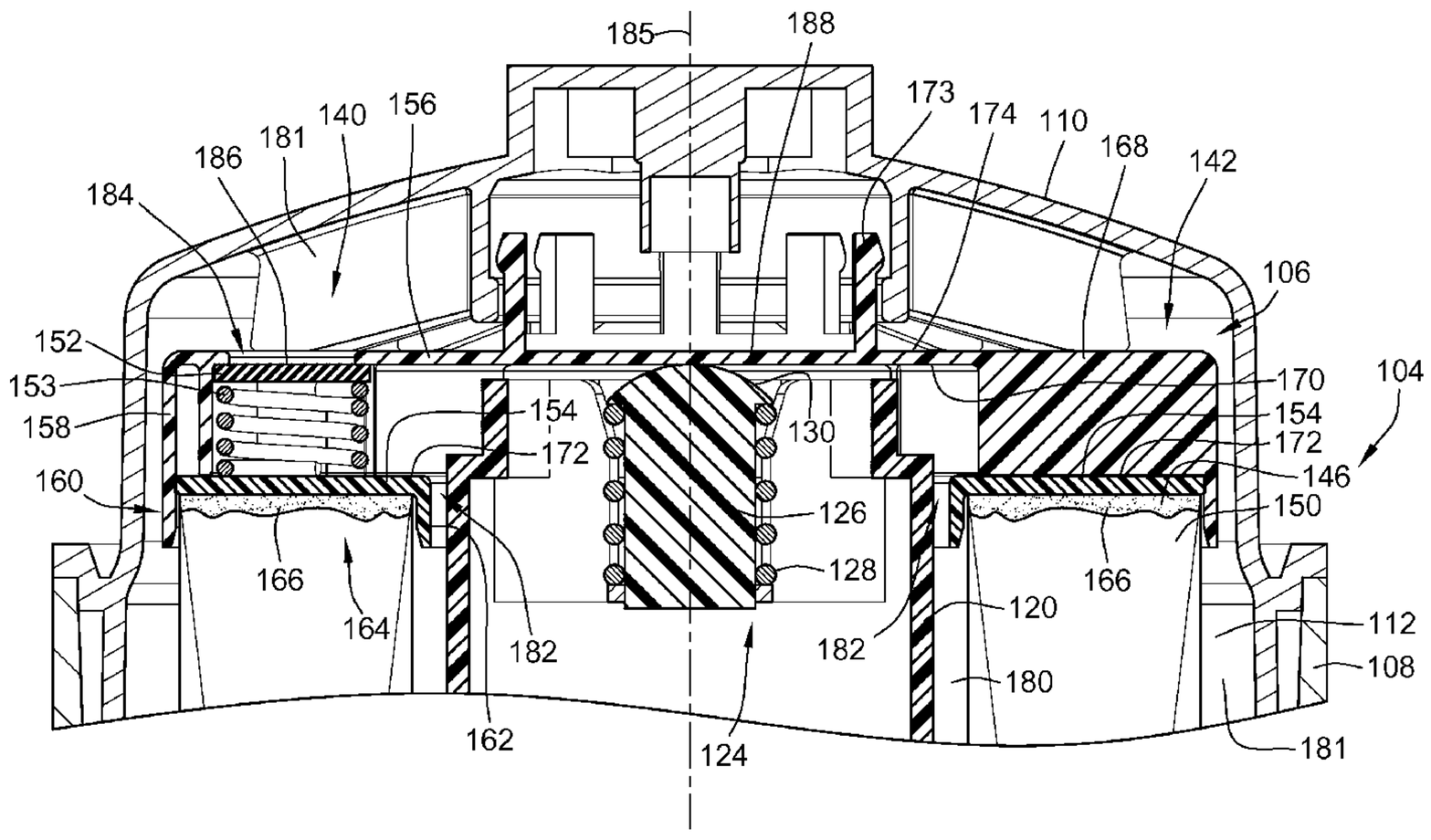

FIG. 1

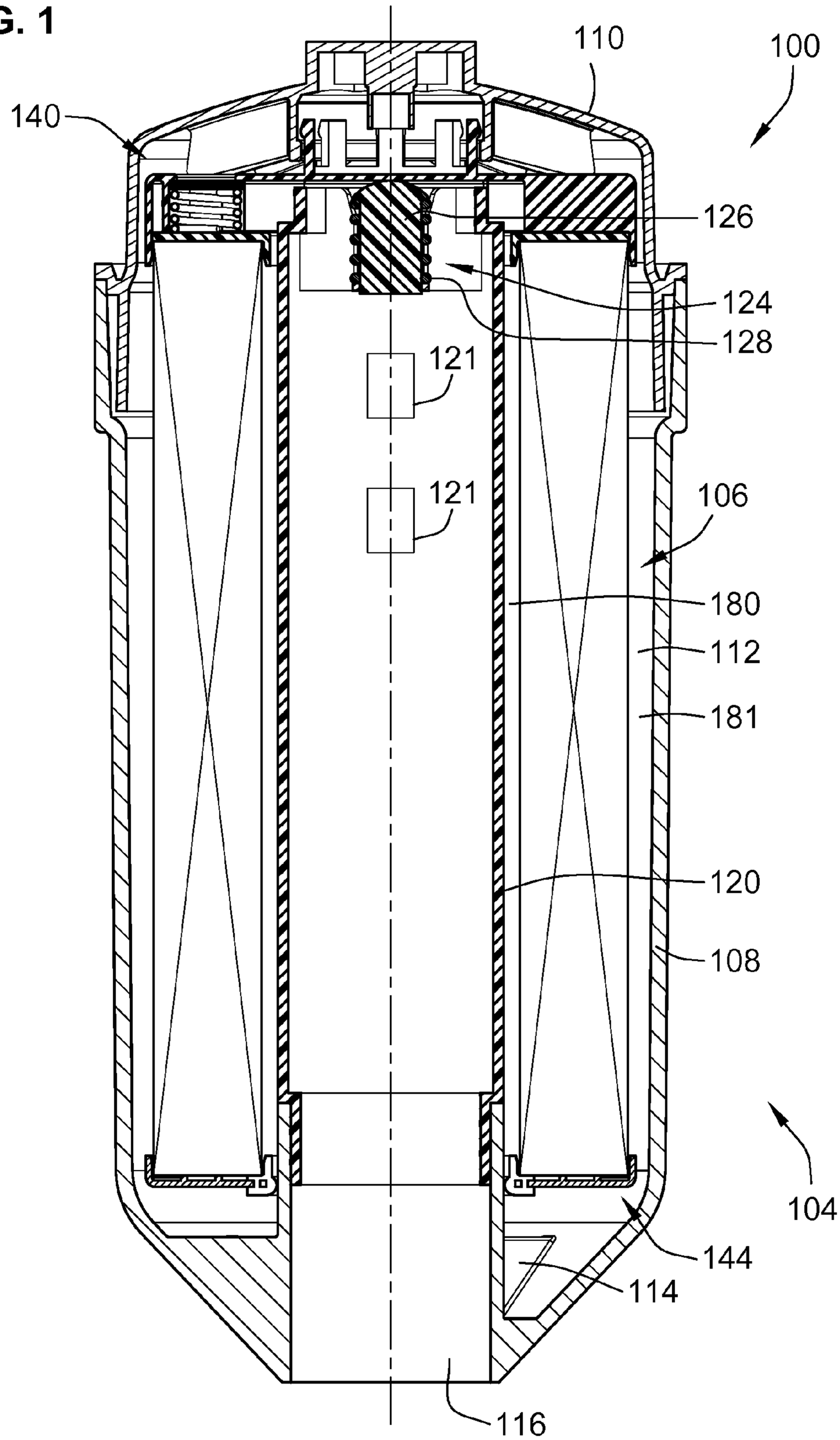
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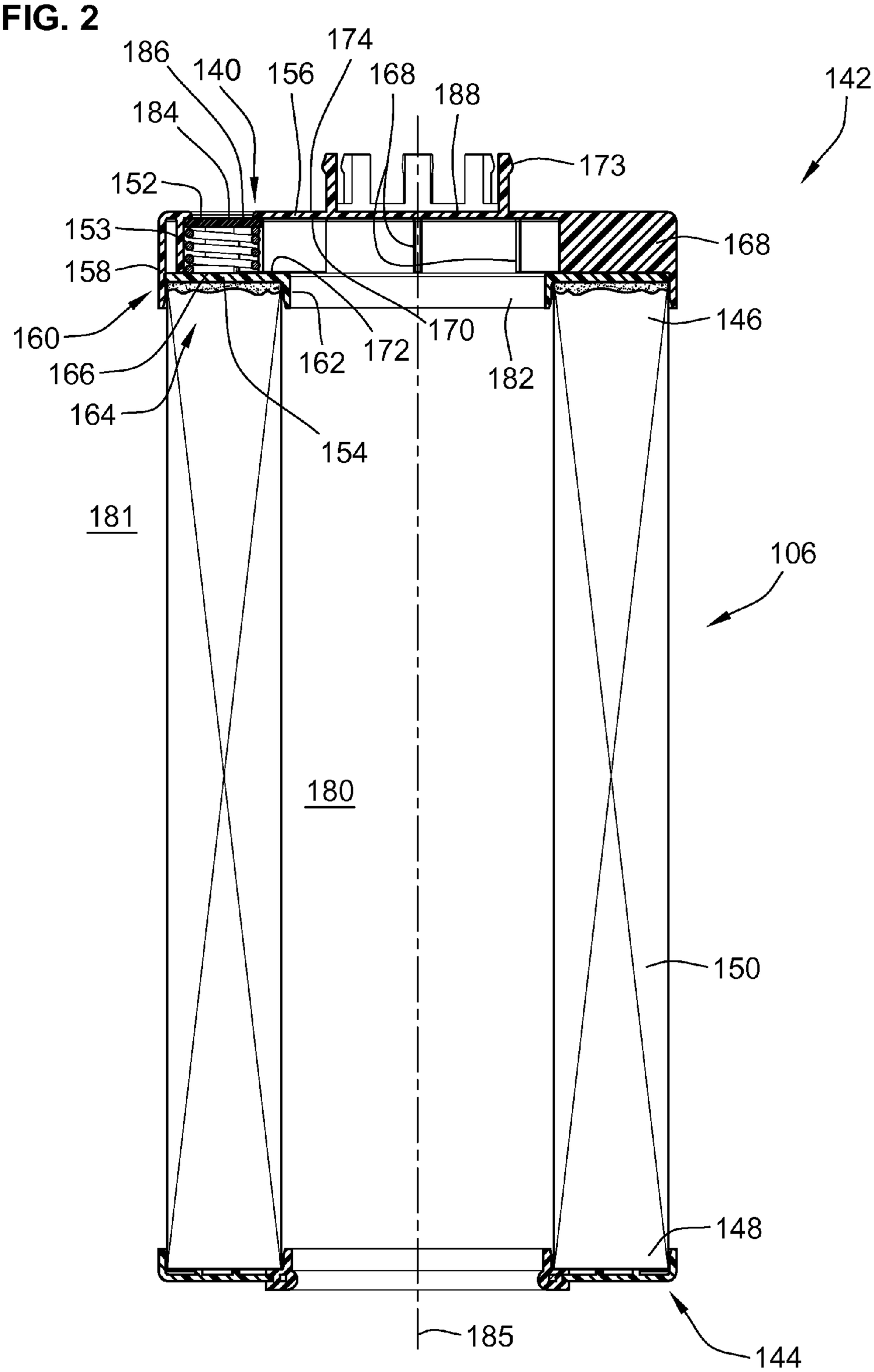
FIG. 2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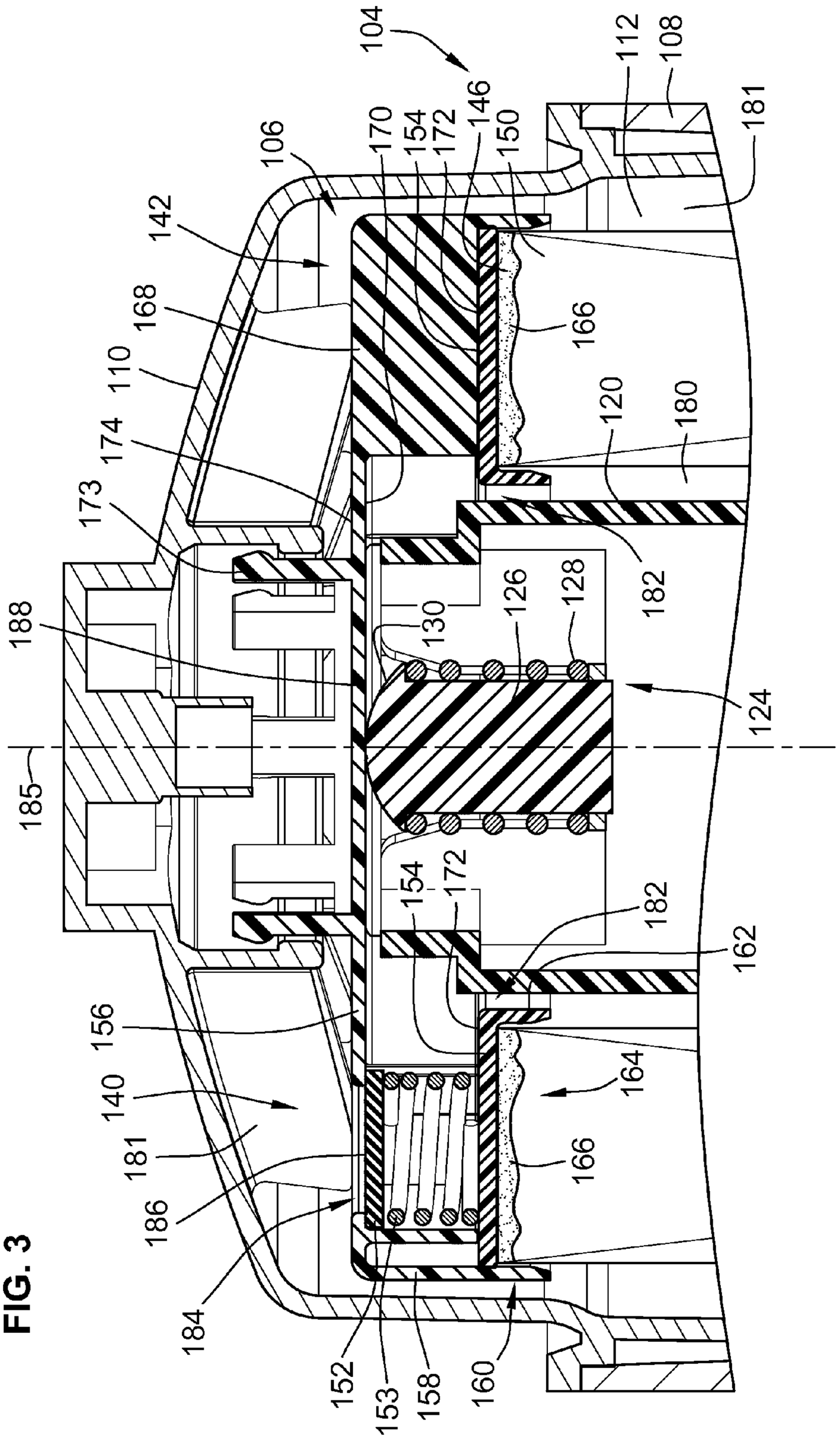
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164

FIG. 3

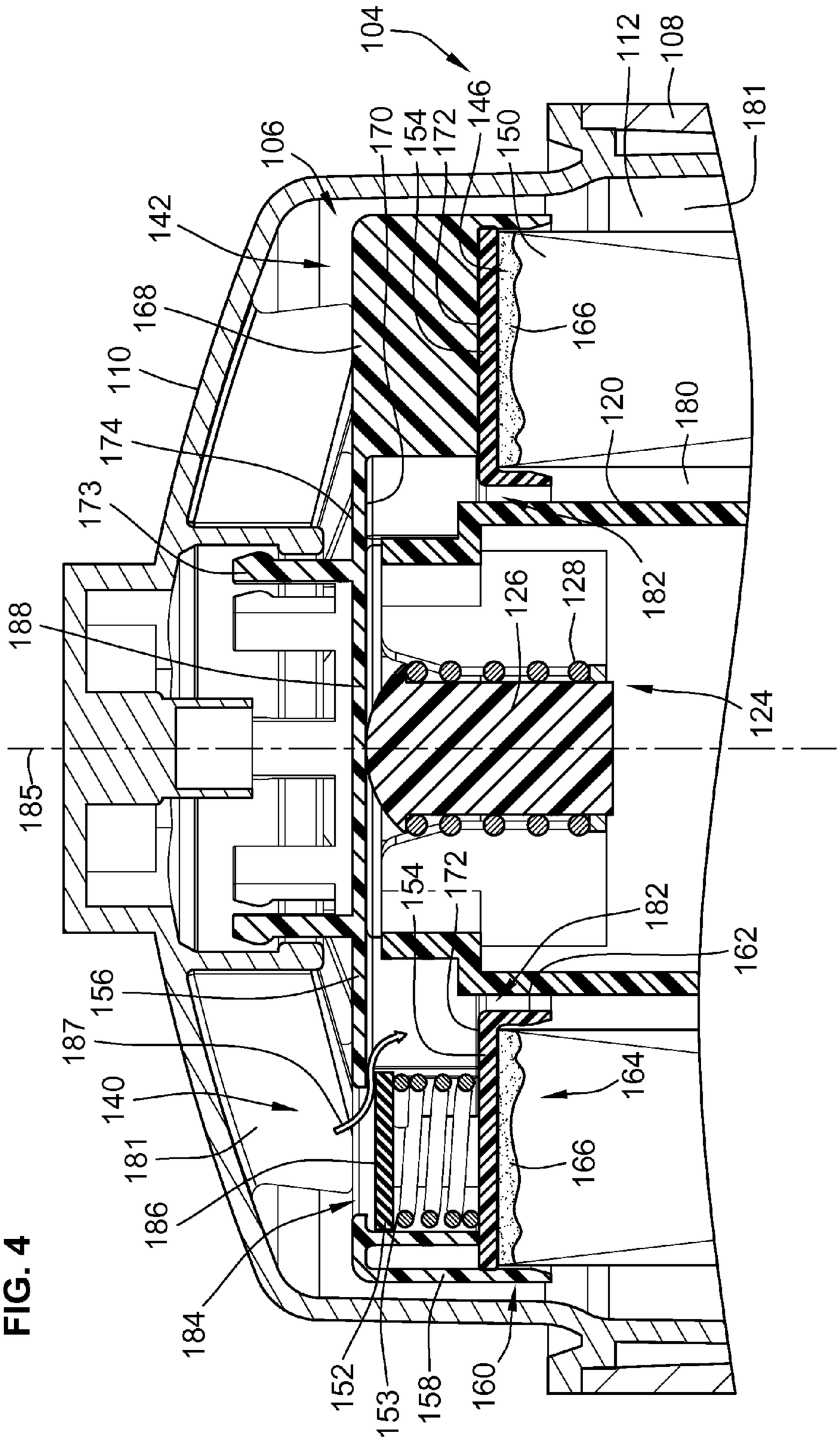
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FIG. 4

FIG. 5

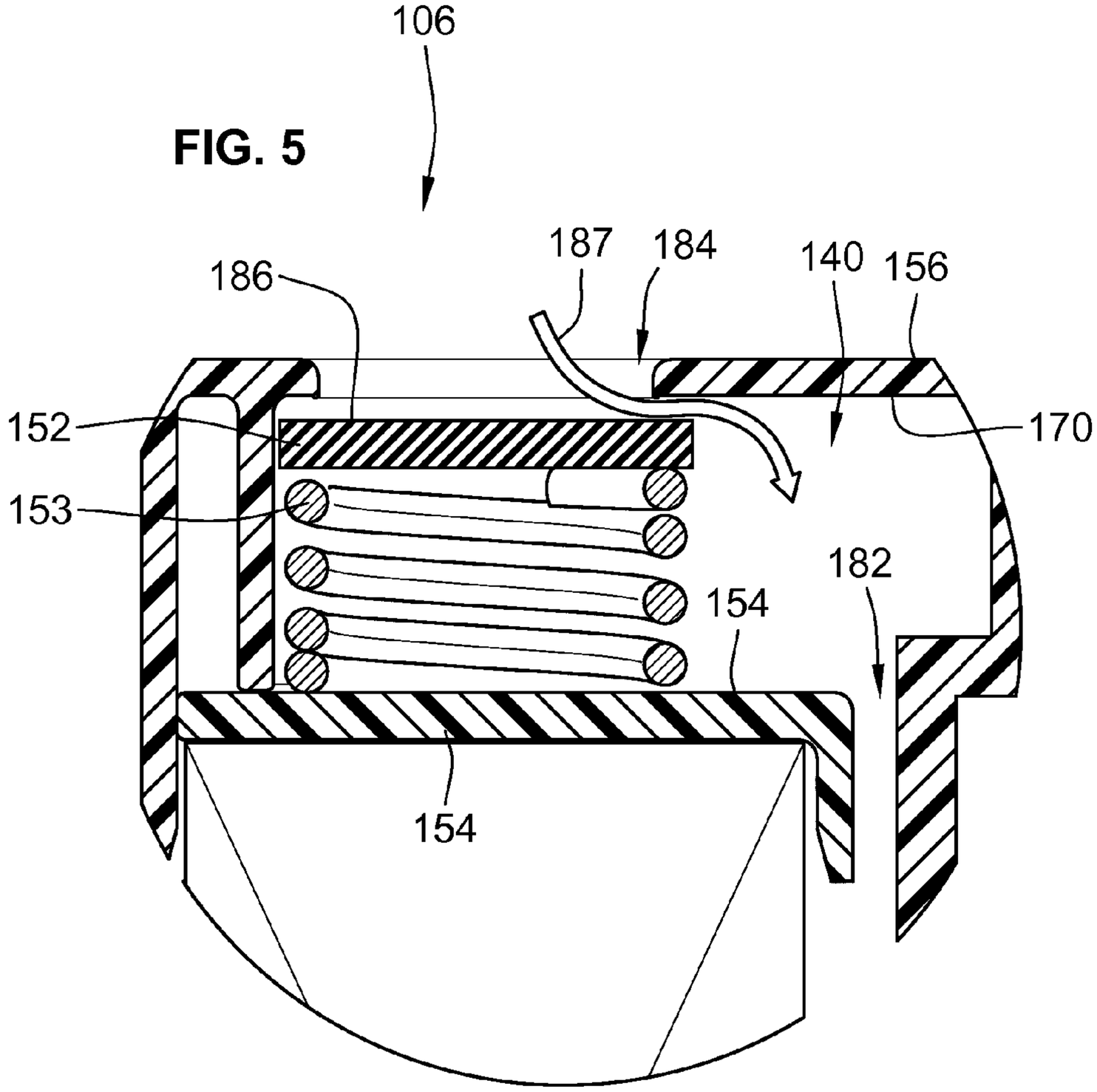
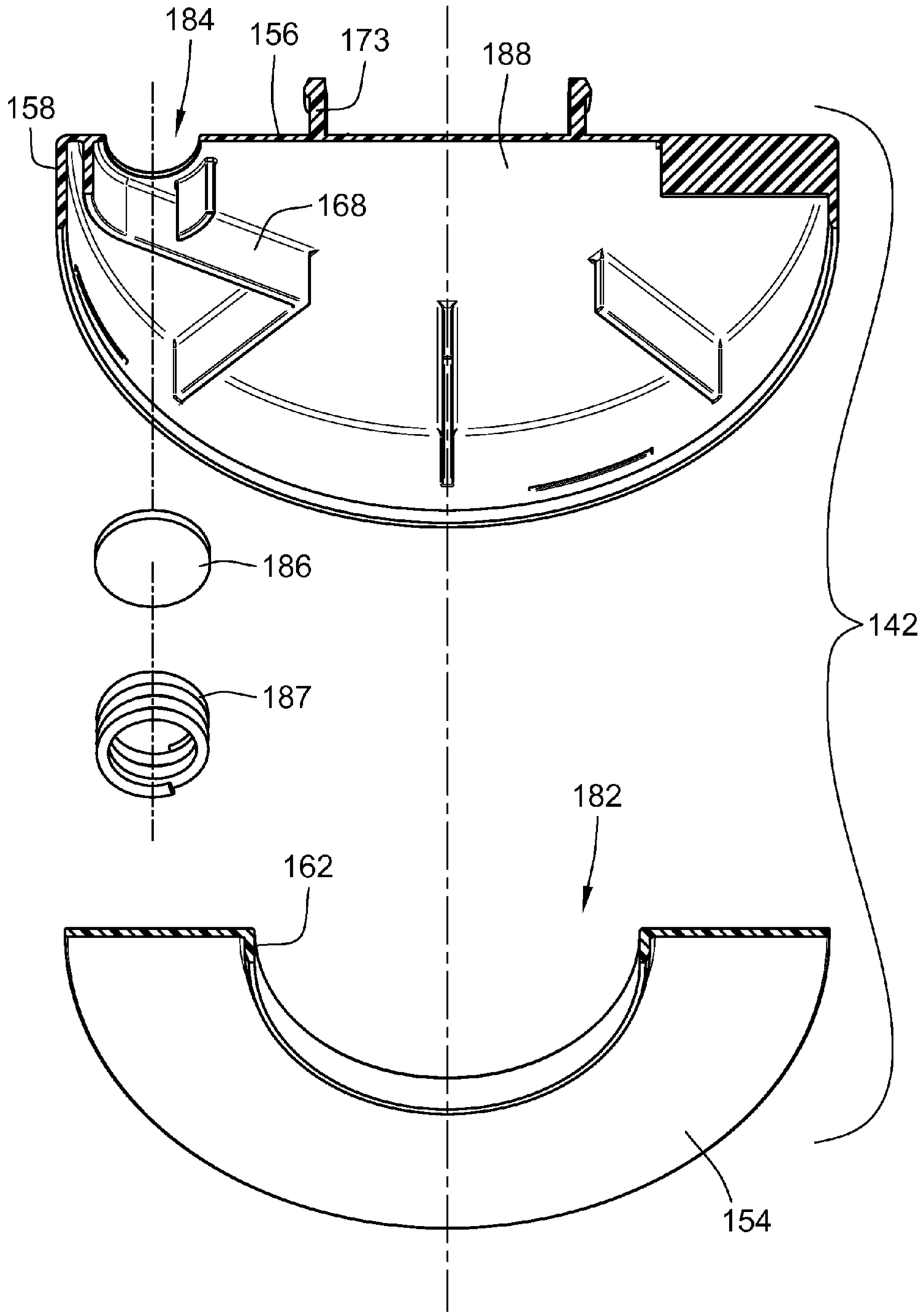
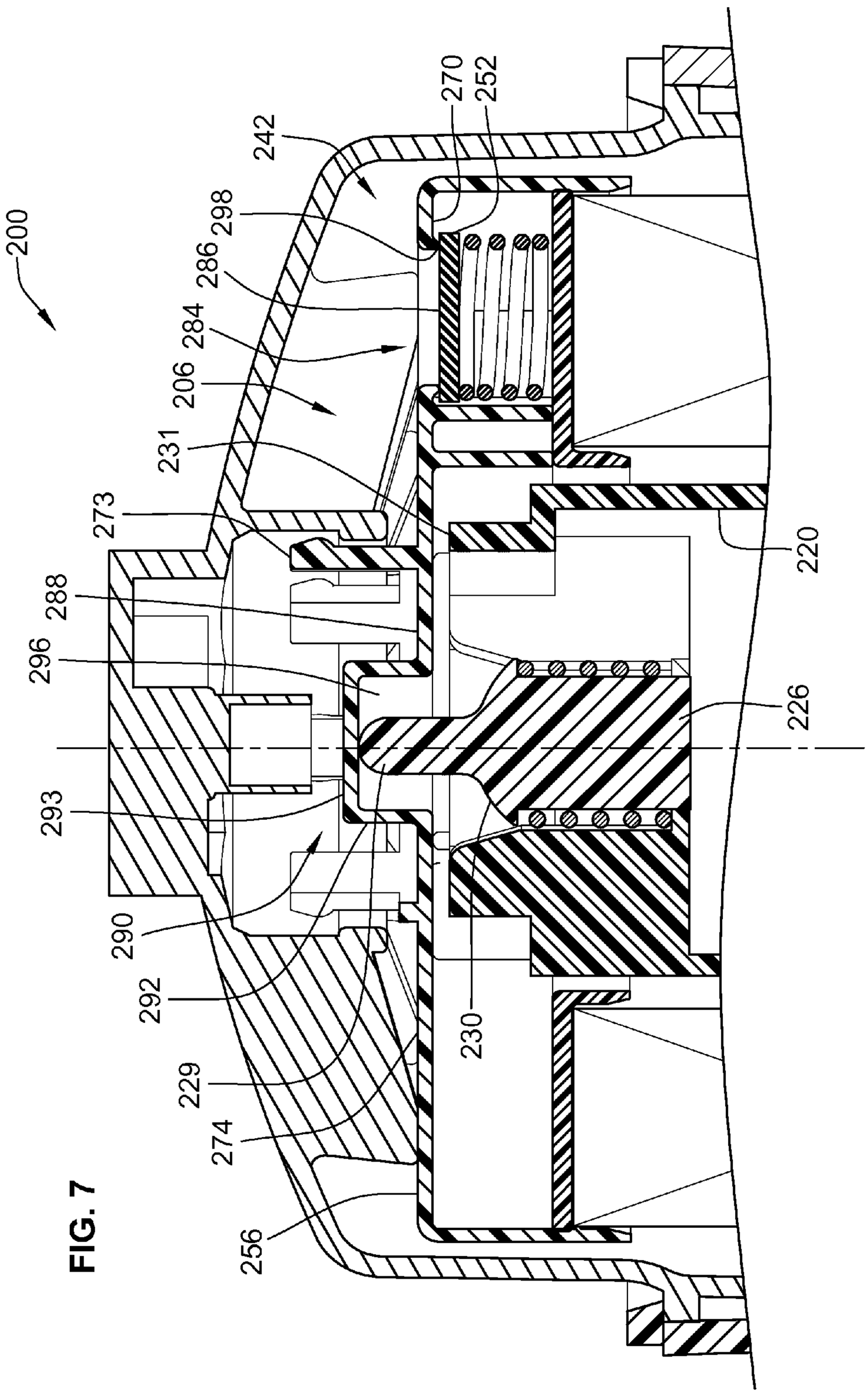


FIG. 6




200
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270
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FIG. 7

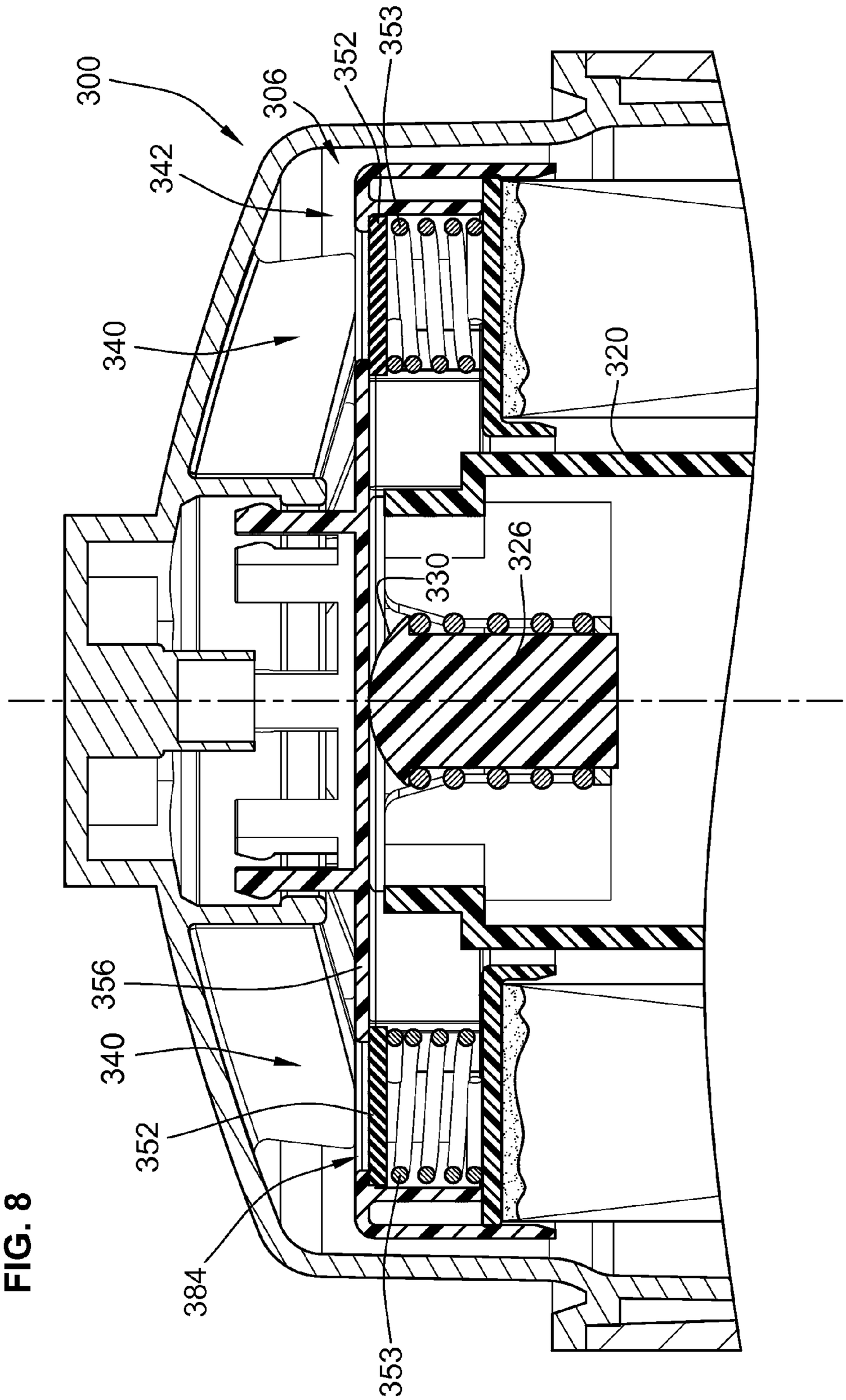


FIG. 8

FIG. 9

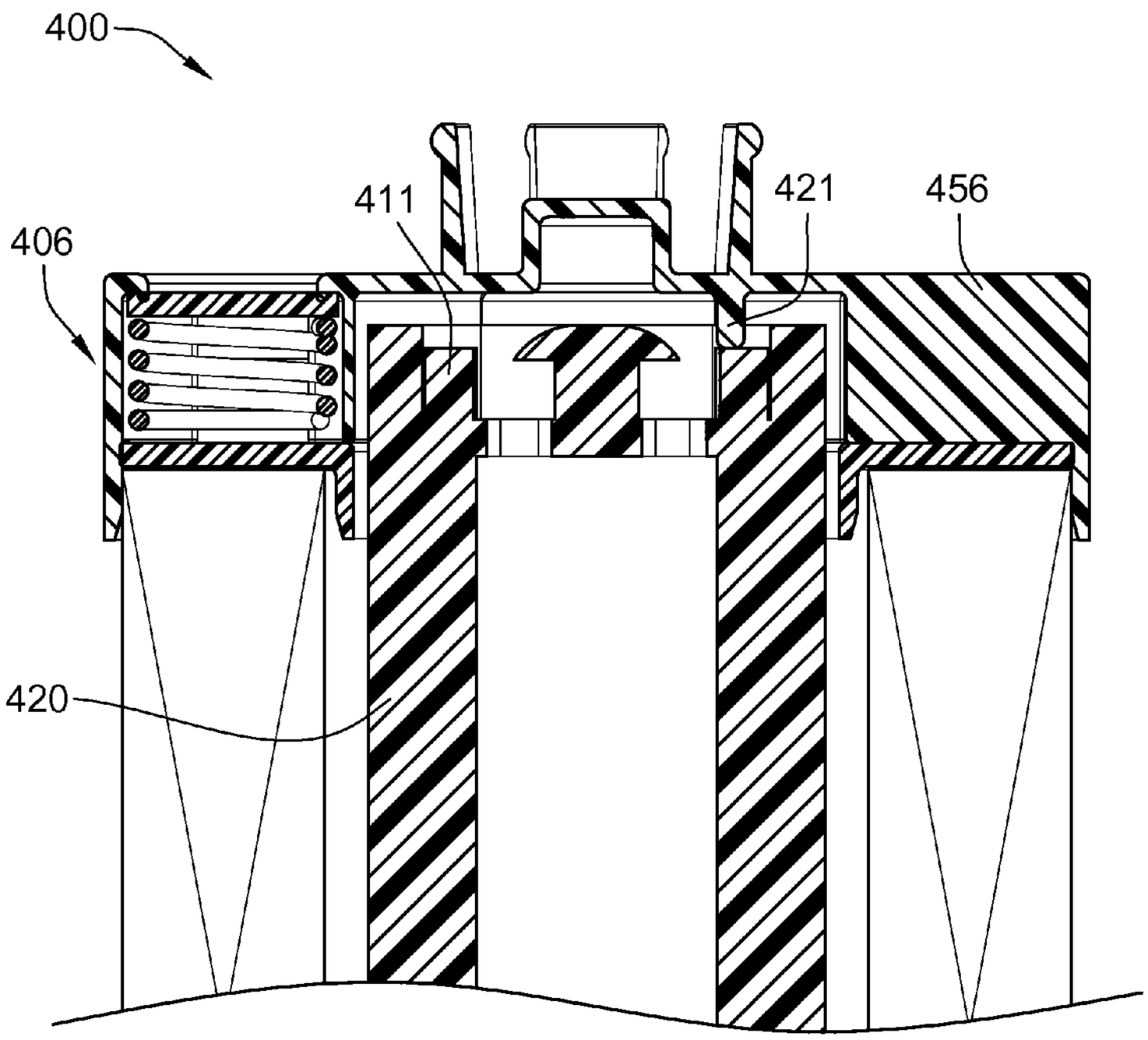
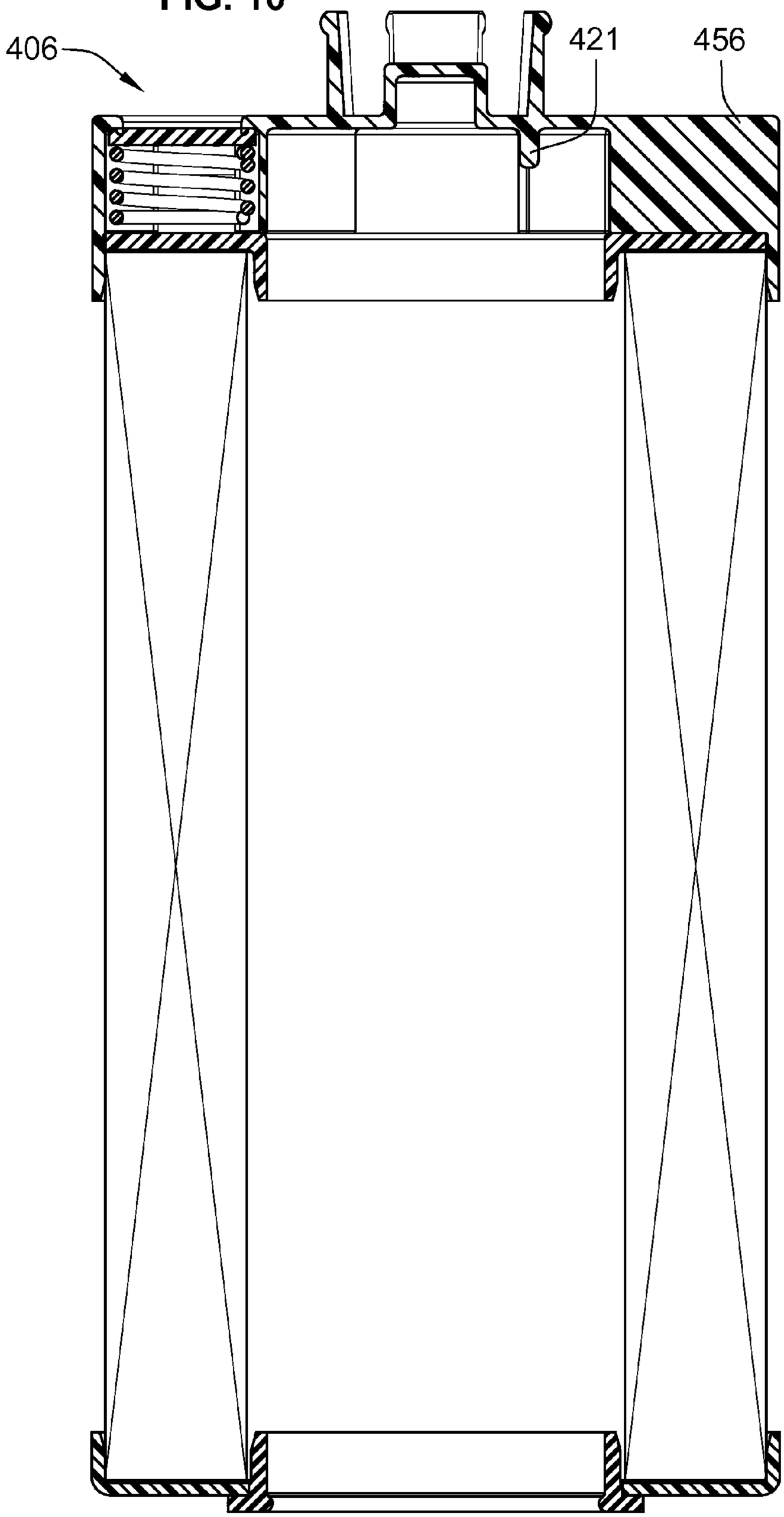


FIG. 10



FILTER END CAP ASSEMBLY WITH BYPASS VALVE

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

This patent application is a divisional of co-pending U.S. patent application Ser. No. 12/436,525, filed May 6, 2009, which is now pending, the entire teachings and disclosure of which are incorporated herein by reference thereto.

FIELD OF THE INVENTION

This invention generally relates to filter arrangements. More particularly, this application relates to filter arrangements for cleaning liquids such as oil or fuel for engines.

BACKGROUND OF THE INVENTION

Fluid filters are commonly used in connection with lubrication and fuel supply systems for internal combustion systems as well as hydraulic systems. The filter assures that downstream systems operate properly. Many systems utilize replaceable filter elements such that when the filtration media or device that actually does the filter becomes spent, it can be easily and cost-efficiently replaced without requiring the entire filter assembly being replaced.

However, upon excess buildup of filtered debris, the flow of fluid through the system can become limited which can hinder the operation and potentially damage the downstream system. As such, some filter assemblies have incorporated a fluid bypass that opens upon excess pressure build up. The bypass acts to allow dirty fluid to short-circuit the filter element of the filter assembly when the filter element becomes clogged with contaminants. Although it is not typically preferred to allow dirty fluid to flow through the filter without being filtered, it is more preferable than preventing a sufficient amount of fluid such as lubricating oil or fuel to flow through the system which can result in catastrophic engine failures.

An example of such a fluid filter is disclosed in U.S. Pat. No. 5,770,054 to Wilhelm Ardes. The '054 patent to Ardes includes a filter element with an upper plastic end cap providing a bypass valve seat that seats against a spring biased valve member on a standpipe in a housing. Due to end cap alignment issues and material issues, there are concerns about reliability of sealing, particularly at the valve seat formed integrally into the plastic upper end cap. Further, because the spring biased valve member forms part of the filter base, the spring biased valve member and its biasing mechanism, typically a coil spring, are not replaced when the spent filter element is replaced. Unfortunately, the Applicants have determined that this can result in additional problems. For example, the biasing mechanism can become worn such that the bypass valve will open under pressure that is too low, i.e. before the filter element becomes sufficiently spent.

Also, International Patent Application PCT/US2008/066739, published as WO 2008/157244 to John Hacker illustrates a further filter assembly using a bypass arrangement. In this arrangement, the filter element includes a valve member that interacts with a valve seat formed by the end cap. The valve member is axially biased against the valve member of the Ardes arrangement that forms part of the filter base to bias the valve member toward a closed position. While a portion of the bypass valve, namely the valve member, is replaced at each maintenance interval, the force biasing the valve member again relies on the biasing mechanism provided by the filter base. Thus, this design once again has the perceived downfalls.

The present invention relates to improvements over Ardes and Hacker and the current state of the art in fluid filters that incorporate a fluid bypass.

BRIEF SUMMARY OF THE INVENTION

The present invention relates to filter assemblies including new and improved bypass arrangements. More particularly, the present invention relates to filter assemblies including new and improved bypass arrangements that improve the reliability of the bypass arrangement and provide an ability to service the entire bypass arrangement. Further yet, the present invention relates to methods of servicing filter assemblies to provide a new bypass arrangement even while a portion of the old bypass arrangement remains part of the filter assembly, albeit useless.

In that regard, in a first embodiment of a method according to the present invention, a method of use for servicing a bypass valve of a filter assembly. The method includes the step of removing a spent filter element from a filter housing of a filter base. The filter base has at least a bypass valve member remaining therewith when the filter element is removed from the filter housing. The method also includes the step of inserting a filter element into the filter housing. The filter element has a complete filter element bypass valve such that the bypass valve member of the filter base of the filter assembly is no longer used in any way for fluid bypass and is no longer a bypass valve member. By providing a bypass valve carried by the filter element, the accuracy and integrity of the bypass valve is not diminished because it is replaced at each maintenance interval.

In one particular implementation, the step of inserting the filter element includes inserting the filter element into the filter housing such that the complete filter element bypass valve does not interact with the filter base. In a more particular implementation, the step of inserting the filter element includes inserting the filter element into the filter housing such that the complete filter element bypass valve is laterally offset from the bypass valve member of the filter base. In an even more particular implementation, the step of inserting the replaceable filter element includes inserting the replaceable filter element into the filter housing such that the complete filter element bypass valve, at least in part, axially overlaps with the bypass valve member of the filter base.

A filter assembly comprising a filter base and a replaceable filter element is also provided. The filter base includes a housing. The replaceable filter element is operably mounted in the housing. The replaceable filter element includes a ring of filter media, a first end cap and a bypass valve. The ring of filter media defines an open interior. The first end cap is secured to a first end of the filter media and defines a flow path fluidly communicating the open interior with an exterior of the replaceable filter element. The exterior of the replaceable filter element is within the housing. The bypass valve has a valve member movable between a closed position preventing fluid flow through the flow path from the exterior to the open interior and an open position permitting fluid flow through the flow path from the exterior to the open interior. The bypass valve also includes a biasing member biasing the valve member toward the closed position.

In one particular implementation, the filter element completely caries a complete valve such that the bypass valve operates entirely free of interaction with the filter base.

In a more particular implementation, the filter base includes an inner support with a spring biased valve member therein that remains with the filter base when the replaceable filter element is removed from the housing. The replaceable filter element is operably mounted over the inner support. The bypass valve does not interact with the spring biased valve member when operably mounted over the inner support. In an even more particular implementation, the first end cap includes a first portion spaced apart from a second portion with the valve member being interposed between the first portion and the second portion. The first portion is a generally annular member defining a first aperture communicating with the open interior and the second portion includes a second aperture. The flow path communicating the first and second apertures when the bypass valve is in the open position.

In an implementation, a free end of the inner support extends through the first aperture. Additionally, the spring biased valve member of the filter base is in the free end of the inner support and is axially exposed. The second portion has a continuous central portion, forming no part of the bypass valve, that extends across first aperture and the free end of the inner support rendering the spring biased valve member of the inner support inoperable for providing fluid bypass. The filter element may include a second end cap secured to a second end of the filter media. The second end cap including a third aperture. The inner support extending through the third aperture.

Further yet, aspects of the invention provide a replaceable filter element. The replaceable filter element can be used to replace a fluid bypass valve every time the filter element is replaced. The filter element includes an annular ring of filter media for filtering fluid. The filter media defines an open interior. The filter element includes a first end cap secured to a first end of the filter media. The first end cap defines a flow path fluidly communicating the open interior with an exterior of the replaceable filter element. The filter element also includes a bypass valve having a valve member movable between a closed position preventing fluid flow through the flow path from the exterior to the open interior and an open position permitting fluid flow through the flow path from the exterior to the open interior and a biasing member biasing the valve member toward the closed position.

In a preferred embodiment, the valve member and biasing member are carried by the first end cap.

In further particular implementations, the first end cap includes a first portion spaced apart from a second portion and the valve member is interposed between the first portion and the second portion. In such an arrangement, the biasing member is operably interposed between the valve member and the first portion of the end cap such that the biasing member biases the valve member toward the second portion. Even more particularly, the first portion may be a generally annular member defining a first aperture communicating with the open interior and the second portion includes a second aperture such that the flow path communicates the first and second apertures.

In a further implementation, the first portion of the end cap is connected to the first end of the filter media and the second portion of the end cap is axially spaced from the first portion. The biasing member biases the valve member away from the first portion and the filter media toward the second portion. The valve member prevents fluid flow through the second aperture in the closed position and permits fluid flow through the second aperture in the open position.

In one embodiment, the first end cap is an assembly of parts with the first portion being attached to the second portion. More particularly, an annular sidewall axially connects the first and second portions. The annular sidewall may form a part of a well that receives the first end of the filter media.

An additional method includes providing a bypass arrangement for permitting fluid to bypass a filter element of a filter assembly comprising the step of inserting a filter element into a filter base, the filter base having, at least a portion of a first bypass valve carried by the filter base, the filter element having a complete second bypass valve such that the at least a portion of a first bypass valve carried by the filter base is no longer used in any way for fluid bypass and is not a bypass valve member.

Other aspects, objectives and advantages of the invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings incorporated in and forming a part of the specification illustrate several aspects of the present invention and, together with the description, serve to explain the principles of the invention. In the drawings:

FIG. **1** is a cross-sectional illustration of a filter assembly according to an embodiment of the present invention

FIG. **2** is a cross-sectional illustration of the filter element of the filter assembly of FIG. **1** with a bypass valve in a closed position;

FIG. **3** is an enlarged partial cross-sectional illustration of the filter assembly of FIG. **1** illustrating the bypass valve of the filter element in a closed condition;

FIG. **4** is an enlarged partial cross-sectional illustration of the filter assembly of FIG. **1** illustrating the bypass valve of the filter element in an open condition;

FIG. **5** is a further enlarged partial cross-sectional illustration of the filter element showing the bypass valve in the open condition; and

FIG. **6** is an exploded illustration of an end cap of the filter element of FIG. **2**;

FIG. **7** is an enlarged partial cross-sectional illustration of a further embodiment of a filter element according to the present invention;

FIG. **8** is an enlarged partial cross-sectional illustration of a further embodiment of a filter assembly according to the present invention; and

FIGS. **9** and **10** are further simplified cross-sectional illustrations of a further embodiment of a filter element and filter assembly according to the present invention.

While the invention will be described in connection with certain preferred embodiments, there is no intent to limit it to those embodiments. On the contrary, the intent is to cover all alternatives, modifications and equivalents as included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** is a cross-sectional illustration of an embodiment of a filter assembly **100** according to the teachings of the present invention. The filter assembly **100** is typically used to filter fluids and more typically liquids and even more typically filtering fuel, lubricants or hydraulic fluid.

The filter assembly **100** generally includes a filter base **104** that is a reusable portion of the filter assembly **100** and a replaceable filter element **106** (also referred to generally as "filter element **106**") that gets replaced at service intervals or when otherwise becomes spent. Thus, the replaceable filter element **106** is removably mountable within filter base **104**.

The filter base **104** includes an annular housing body **108** to which a housing cover **110** is releasably secured. As used herein, "annular" can refer to any ring like structure and need not be circular. It includes, by way of non-limiting example, polygonal shapes, elliptical shapes, oblong and oval shapes as well. The housing body **108** and housing cover **110** combine to form a filtration chamber **112** in which the replaceable filter element **106** is housed. The housing cover **110** may be removed from the housing body **108** during maintenance to provide access to an old spent filter element for removal and to allow new clean filter elements to be installed.

The filter element **106** separates a dirty fluid inlet **114** from a clean fluid outlet **116** causing any fluid flow through the filter assembly **100** and particularly filter base **104** to pass through the filter element **106** during normal operation such that the fluid is cleaned by the filter element **106**.

The filter base **104** of the illustrated embodiment further include a central support **120** about which the replaceable filter element **106** is operably mounted. The central support **120** is porous or includes apertures **121** that permits fluid to flow to the clean fluid outlet **116** after it has passed through filter element **106**.

The central support **120** includes a bypass valve arrangement **124** carried in a free end thereof. The bypass valve arrangement **124** includes a valve member **126** and a biasing member **128**, illustrated in the form of a coil spring. The valve member **124** includes an axial sealing surface **130** (see FIG. **3**) that is axially exposed when no filter element is inserted into the filtration chamber **112**. The sealing surface **130** is axially exposed because it is intended, in other arrangements not covered by this invention, to cooperate with cooperating sealing structure of a corresponding filter element (not shown), such as illustrated in Ardes '054, to provide a complete fluid bypass valve when the filter element is installed. In those arrangements, the sealing surface **130** is urged against and seated against a cooperating sealing surface bounding an aperture through the filter element to prevent fluid bypass during normal operation. Dirty fluid will pass through the aperture in the filter element, typically through an end cap of the filter element, and act on the axial sealing surface **130**. The biasing member **128** acts to axially bias the valve member **126** toward the housing cover **110** and oppose the forces provided by the dirty fluid during normal operation.

In those arrangements such as disclosed in Ardes '054, when the filter element becomes sufficiently clogged, the fluid pressure external to the filter element will continually increase due to insufficient flow until a predetermined pressure is reached at which time the fluid will bias the valve member axially away from the housing cover **110**. This will break a seal between the filter element and the valve member **126** allowing fluid bypass.

Unfortunately, neither the valve member **126** nor the biasing member **128** are replaced at service intervals as these portions of the bypass valve arrangement are provided by the filter base **104** itself, namely the central support **120**. Thus, the biasing member **128** can wear and become weakened allowing premature actuation of valve member **126** and thus allowing premature dirty fluid bypass. Similarly, the valve member sealing surface **130** may be come damaged reducing its ability to seal against the cooperating sealing structure of the corresponding filter element (i.e. the filter element of Ardes '054).

The replaceable filter element **106** according to an embodiment of the present invention includes the entire bypass valve **140**, not just a portion against which valve member **126** of the filter base **104** acts, and in fact no portion against which valve member **126** acts. Thus, in filter assembly **100**, the spring biased valve arrangement **124** is rendered useless when combined with the filter element **106** such that the bypass valve arrangement **124** forms no part of the bypass valve and the valve member **126** of the filter base **104** is no longer a bypass valve member at all. That structure is now merely excess parts that have no function.

FIG. **2** is a cross-sectional illustration of one filter element **106** according to the teachings of the present invention. The replaceable filter element **106** generally includes first and second end caps **142**, **144** operably connected to first and second ends **146**, **148**, respectively, of an extension of filter media **150**.

With reference to FIGS. **2** and **3**, the bypass valve **140** includes a valve member **152** and a biasing member **153** that are entirely carried by the filter element **106**, and as illustrated, are carried by first end cap **142**. In other words, the complete bypass valve of the filter assembly **100** is provided by the filter element **106**. As will be more fully explained below, the valve member **152** interacts with the rest of first end cap **142** to provide the bypass valve **140**. However, in other embodiments, the bypass valve **140** could be provided by other portions of the filter element, such as through the filter media or carried by the second end cap **144**.

In the illustrated embodiment, the first end cap **142** includes first (axially inner) and second (axially outer) portions **154**, **156** that are axially spaced apart from one another. The valve member **152** and biasing member **153** are axially interposed between the first and second portions **154**, **156**.

An annular axially extending outer sidewall **158** axially connects the first portion **154** to the second portion **156**. In a preferred embodiment, the axially extending outer sidewall **158** and the second portion **156** are formed as a one-piece construction. As used herein, one-piece construction shall not be construed to include a plurality of individual components connected together. The structures must be formed as a continuous piece, i.e. as a single molded part or stamped from a single piece of material. In a preferred arrangement, the first portion **154** is either press-fit or snap-fit (by way of cooperating structure such as for example inward and outward radially projecting ribs, projections or grooves) engaged within a cavity formed by the axially extending outer sidewall **158**.

The axially extending outer sidewall **158** includes a free end portion **160** that extends axially downward beyond the first portion **154**, i.e. toward the second end cap **144**. Additionally, the first portion **154** preferably includes an annular axially extending inner sidewall **162** extending downward, i.e. toward second end cap. The inner and outer sidewalls **158** (particularly free end portion **160**) and first portion **154** cooperate to form a well **164** for receiving the first end **146** of the filter media **150**. In one embodiment, an adhesive agent **166** is used to secure the filter media in well **164**. The adhesive agent **166**, which may be, by way of non-limiting example only, a plastisol or polyurethane foam, also seals the junction between the first portion **154** and the axially extending outer sidewall **158** to prevent fluid leakage therebetween.

In alternative embodiments, the filter media **150** could be directly embedded into the end caps **142**, **144**. Also, both of the first and second portions **154**, **156** could be formed as a single body that is a one-piece construction, rather than a plurality of components coupled together.

To assist in axially locating the first portion **154** relative to the second portion **156**, the first end cap **142** also includes a plurality of axially extending spacing walls **168** that are laterally/angularly spaced apart permitting fluid flow therebetween. The axially extending spacing walls **168** are also formed, in the illustrated embodiment, with the second portion **156** into a continuous piece and extend axially from an inner surface **170** of the second portion **156** toward the first

portion **154**. The free ends of the spacing walls **168** axially abut an axially outer surface **172** of the first portion **154**. However, the spacing walls **168** could be entirely omitted or could be independently formed from either the first or second portions **154**, **156** or could be continuously formed with first portion **154**.

Additionally, the first end cap **142** includes a plurality of axially extending attachment prongs **173** for attaching the replaceable filter element **106** to the housing cover **110** as illustrated in FIGS. **1** and **3**. The attachment prongs **173** extend axially outward from an outer surface **174** of the second portion **156** that is opposite inner surface **170**. The prongs **173** can include cooperating structure, such as the illustrated radial projections or protrusions that cooperate with corresponding structure of the housing cover **110**. However, other structure could be incorporated to secure the replaceable filter element **106** to the housing cover **110**. Such securement facilitates removal of spent filter elements and insertion of new filter elements during maintenance. More particularly, the filter element **106** that is spent remains connected to the housing cover **110** during removal.

The bypass valve **140** has a closed condition, illustrated in FIGS. **2** and **3**, in which dirty fluid (external to the filter element **106**, i.e. in area designated generally by reference numeral **181**, when installed in filter base **104**) is prevented from bypassing filter media **150**. The bypass valve **140** also has an open configuration, illustrated in FIGS. **4** and **5**, in which dirty fluid is permitted to bypass the filter media **150** and pass into the filter element **106**.

The bypass valve **140** is formed in a flow path operably communicating the interior **180** of the filter media **150** with the exterior **181** of the filter media **150** without passing through filter media **150**. The flow path in the illustrated embodiment is generally formed between a first aperture **182** and a second aperture **184**.

The first aperture **182** is formed through the first portion **154**, is generally bounded by inner sidewall **162** and opens into the interior **180** of the filter media **150**. The first aperture **182** is generally centered on the first portion **154** and is co-axial with a central axis **185** of the filter media.

The second aperture **184** is formed through the second portion **156** and, in the illustrated embodiment, is laterally spaced apart from the first aperture **182** and toward sidewall **158** such that the second aperture **184** is radially interposed between the sidewall **158** and second first aperture **182**. In the illustrated embodiment, the second aperture **184** does not radially overlap the first aperture **182**. Further, the second aperture **184** is radially spaced outward from prongs **173**. To permit fluid communication and mounting of valve member **152**, the second aperture **184** is angularly positioned between adjacent ones of the axially extending spacing walls **168**. The axially extending spacing walls **168**, or similar projections, can be used to align the valve member **152** with second aperture **184** (see generally FIG. **6**).

As illustrated in FIGS. **2** and **3**, the bypass valve **140** includes the valve member **152** and the biasing member **153** illustrated in the form of a coil spring and also referred to herein as "coil spring **153**." Coil spring **153** biases valve member **152** toward the external side of the structure in which aperture **184** is mounted. As such, coil spring **153** biases valve member **152** away from the first portion **154** and toward the second portion **156**. As illustrated, coil spring **153** is axially interposed between the valve member **152** and top surface **172** of the first portion **154**.

During normal operation, pressure of the dirty fluid external to the filter element **106** is sufficiently low that the biasing force acting on the valve member **152** is greater than the force applied by the dirty fluid pressure. Thus, during normal operation, the valve member **152** is biased axially against the inner surface **170** of the second portion **156**. The valve member **152** is sized large enough to entirely overlap second aperture **184** to seal it and prevent fluid flow therethrough.

When the media **150** of the filter element **106** becomes spent, contaminants will resist flow of fluid therethrough causing the pressure of the dirty fluid external to the filter element **106** to rise. When the pressure of the dirty fluid reaches a predetermined level, the force applied by the dirty fluid to the top surface **186** (also referred to as a sealing surface) of the valve member **152** will be sufficient to overcome the biasing force of coil spring **153**. This will cause the bypass valve **140** to open (see FIG. **4**) and permit fluid flow along the flow path illustrated as arrow **187**. This allows dirty fluid to bypass the filter media **150** to maintain a desired amount of fluid flow through the filter assembly **100** to prevent damage or decrease in performance of downstream systems utilizing the fluid.

In the illustrated embodiment, the valve member **152** is a flat disk. However, other shapes could be used. The top surface **186** can be contoured, such as for example rounded, conical, or tapered, so that it is guided into second aperture **184** to form a good seal therewith. Likewise, other biasing members could be used, such as for example a wave spring, a cantilevered resilient beam.

Additionally, the valve member **152** and biasing member (illustrated as two separate components, i.e. the disk and the spring) could be formed from a single piece. For example, a sufficiently rigid yet resilient continuous piece of foam could be used that will flex or compress when a sufficient amount of pressure is applied to the foam. Thus, the single continuous piece of foam would be considered to have both a valve member and a biasing member.

In the illustrated embodiment, the second portion **156** of the first end cap **142** is generally an imperforate disk-shaped portion, except for second aperture **184**. Because aperture **184** is radially spaced from the center of the second portion **156** includes a continuous imperforate section **188** that extends entirely across the first aperture **182** of the first portion **154**. The resilient mounting prongs **173** extend axially outward from this imperforate section **188**.

With reference to FIGS. **3** and **4**, when the filter element **106** according to the teachings of the present invention are mounted within filter base **104**, the filter element **106** renders the bypass valve arrangement **124** and particularly valve member **126** and biasing member **128** useless such that the valve member **126** is deactivated and no longer a valve member at all, but is merely superfluous and unused.

When the filter element **106** of the illustrated embodiment is mounted within filter base **104**, the free end of the central support **120** passes axially through first aperture **182**. In this configuration, the central support **120** and particularly the valve arrangement **124** mounted in the free end of central support **120** aligns with the imperforate section **188** of end cap **156**, thus preventing any dirty fluid from interacting with valve member **126**.

In this configuration, bypass valve **140** of the filter element **106** is radially offset and spaced outward from bypass valve arrangement **124** of the filter base **104**. Additionally, the bypass valve **140** of the filter element **106** axially, at least in part, overlaps with the bypass valve arrangement **124** of the filter base **104**.

Thus, in this embodiment, the bypass valve **140** of the present invention in no way interacts with the filter base **104** and is completely provided by the filter element and is not provided, in part, by the filter base **104**.

While not shown, the first end cap **142** could also include axially extending protrusions for engaging a locking member of a support tube. Such a locking member is illustrated in U.S. Pat. No. 6,986,426 to Clausen et al., entitled Extension and Locking Assembly for Dripless Element, and Container Therefore, the teachings and disclosure of which are incorporated herein by reference thereto. Whether or not such a locking member would be associated with a bypass valve member of the filter base, interaction of such an axially extending protrusion would not be using the bypass member **126** in any way to provide a fluid bypass valve.

Referring to FIG. **2**, the second end cap **144** includes a seal member for radially sealing against internal support **120**.

Because the filter assembly **100** of the present invention incorporating the filter element **106** discussed above does not utilize any portion of the bypass valve arrangement **124** of the filter base **104**, all components of the bypass valve **140** are replaced at all maintenance intervals.

Embodiments of the present invention also relates to methods of use for servicing the bypass valve **140** of filter assembly **100**. One method includes a first step of removing a spent filter element (this filter element could be one according to filter element **106** discussed above, or could be one similar to that taught by Ardes '054 or similar elements) from the filter housing **108** of the filter base **104**. As discussed above, the filter base **104** includes at least a bypass valve member **124**. The step of removing the spent filter element keeps the bypass valve member **124** with the filter base. After the spent filter element is removed, the method includes the step of inserting a replaceable filter element **106** into the filter housing **108**, the replaceable filter element **106**, as discussed above, having a complete filter element bypass valve **140** such that the bypass valve member **126** of the filter base **104** of the filter assembly **100** is no longer used in any way for fluid bypass and is not a bypass valve member.

In embodiments of the method using the filter element **106**, the step of inserting the replaceable filter element **106** may include inserting the replaceable filter element **106** into the filter housing **108** such that the complete filter element bypass valve **140** does not interact with the filter base **104**.

In embodiments of the method using the filter element **106**, the step of inserting the replaceable filter element **106** may include inserting the replaceable filter element **106** into the filter housing **106** such that the complete filter element bypass valve **140** is laterally offset from the bypass valve member **126** of the filter base **104**.

Further yet, the method may include inserting the replaceable filter element **106** into the filter housing **108** such that the complete filter element bypass valve **140**, at least in part, axially overlaps with the bypass valve member of the filter base. Further, the filter element **106** may be inserted such that a distal end of a support **120** may align with an impervious or continuous portion **188** of the filter element **106** such that no fluid flow, normal flow or bypass flow flows axially through the filter element **106** towards the free end of the inner support **120**.

FIG. **7** illustrates a partial simplified cross-sectional view of an alternative embodiment of a filter assembly **200** according to the present invention. The current embodiment is substantially similar to the filter assembly **100** of the previous embodiments. However, this filter assembly **200** has a slightly different filter element **206** that will be more fully described below. The present embodiment has a slightly different bypass valve member **226** and top end cap **242**.

Valve member **226** is carried by the central support **220** and has an axially extending projection **229** that extends axially outward from axial sealing surface **230**. As illustrated, this axially extending projection **229** extends axially outward beyond the distal end **231** of the central support **220**.

The filter element **206** includes a top end cap **242** that is substantially similar to the top end cap **142** of the prior embodiment. However, the second portion **256** of this embodiment does not have a substantially planar outer surface **274** (excluding attachment prongs **273**). More particularly, the central imperforate section **288** of the second portion is not a planar portion as illustrated in the prior embodiment. More particularly, this imperforate section **288** includes an axially extending receiver portion **290**. The axially extending receiving portion **290** includes an annular sidewall portion **292** and a top portion **293** that extends generally perpendicular to the annular sidewall portion **292**. The thickness of the annular sidewall **292** and top portion **293** is substantially constant. Therefore, due to this arrangement, the axially extending portion **290** forms an internal cavity **296**. This cavity **296** receives the axially extending projection **229** of the valve member **226** of the filter base because there is no aperture through this central imperforate section **288** to accommodate the axially extending projection **229**. The axially extending receiver portion **290** is generally circumscribed by the axially extending prongs **273**. However, axially extending receiver portion **290** is radially spaced inward from the attachment prongs **273**. As cavity **296** receives the axially extending projection **229** of the valve member **226**, the cavity opens toward the interior of the filter element **206**.

The second portion **256** of end cap **242** also defines a sealing seat **298** in its inner surface **270**. This sealing seat **298** is an annular projection having a tapered contour. The tapered contour has a wider base proximate the second portion **256** and a narrower tip forming a distal end of the sealing seat **298**. The annular tip engages the top surface **286** of valve member **252**. The tapered arrangement of sealing seat **298** provides a focused contact point (or line) between the seat **298** and the valve member **252** to increase sealing therebetween. The sealing seat **298** bounds and generally defines second aperture **284** in the second portion of the end cap **242**.

FIG. **8** illustrates a further embodiment of a filter assembly **300** including a further filter element **306**. This filter assembly **300** is substantially similar to that of the embodiment illustrated in FIG. **3**. However, the filter element **306** has a slightly different configuration.

In this embodiment, the filter element **306** includes a top end cap **342** that is similar to the end caps of previous embodiments except that includes a plurality of bypass valves **340** for permitting fluid bypass in the event that too significant a pressure is required to pump fluid through the filter media of the filter element, such as during cold start or when the filter element becomes sufficiently clogged or spent due to use and filtering of particulates from the fluid flowing therethrough.

The bypass valves **340** in the illustrated embodiment are identical and include identical vale members **352** that are acted on by identical biasing mechanisms, i.e. coil springs **353**. By using a plurality of bypass valves **340** the ultimate size of the fluid bypass arrangement provided by the filter element **306** can be increased due to the increased area presented by the plurality of openings **384** passing through the second end cap portion **356** of the end cap **342**.

By removing the requirement of relying on an interaction of the valve member **326** housed in the support **320**, this ability to provide a desired bypass valve cross-sectional area is available. In prior arrangements, the filter element was required to provide an aperture through the end cap that was closely sized to the sealing surface **330** of the valve member **326**. As such, construction of the bypass valve was limited by the mating structure provided by the filter base.

Further, by providing multiple bypass valves **340** the bypass arrangement, provided by the plurality of bypass valves **340**, can be tuned for various conditions. For example, a first on the bypass valves **340** could have different spring constants or alternatively openings **384** having different sizes such that they will open at different pressure values such that there is a sequential, not simultaneous, opening of the various bypass valves **340**. It may be necessary to have positive stops for various ones of the bypass valves **340** so as to limit the opening displacement of the bypass valve **340** so as to allow pressure to build above a given pressure rather than continuously opening the bypass valve **340** configured to open under less pressure.

Again, this could be highly beneficial such as to provide a first bypass valve **340** that opens under cold-start conditions due to high pressures generated due to cooler fluid. Once the fluid is heated, the bypass valve **340** would close again. However, if the filter element **306** becomes sufficiently plugged due to filtered particles or particulates, the first bypass valve **340** will open. Then, if the filter element **306** becomes further plugged increasing the pressure of the fluid external to the filter element **306**, the second bypass valve **340** could open to permit an increased amount of bypass flow.

Further, while illustrated as both being formed by a single end cap arrangement, other filter elements according to the present invention could include one or more bypass valves in one end cap and one or more bypass valves in another end cap to provide the plurality of bypass valves.

FIGS. **9** and **10** are highly simplified, partial, schematic representations of a further embodiment of a filter assembly **400** (FIG. **9**) and filter element **406** (FIG. **10**) according to the present invention.

This embodiment illustrates that the filter element **406** may include a means for actuating a latch or other device of the filter base. For instance, the support **420** may include a collar **411** that must be actuated prior to allowing any fluid flow to pass therethrough during normal operation. As such, the filter element **406** includes an actuation projection **421** that engages and axially biases the collar **411** axially when the filter element **406** is mounted over central support **420**. In the illustrated embodiment, the actuation projection **421** is formed by the second end cap **456** into a one-piece construction.

Further, while the various illustrations illustrate a gap formed between the second end cap portion and the support, it should be noted that this need not be the case in other embodiments. For example, the first (inner) end cap portion could seal to the outer surface of the support such that fluid is required to flow through the portion of the support positioned axially between the first and second end cap portions. Typically, this will occur when the fluid internal to the filter element enters the central support through an axial end thereof. However, it could pass through apertures formed in the radial sidewalls of the central support.

All references, including publications, patent applications, and patents cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

The use of the terms "a" and "an" and "the" and similar referents in the context of describing the invention (especially in the context of the following claims) is to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

What is claimed is:

1. A filter assembly comprising:

a filter base including a housing;

a replaceable filter element operably mounted in the housing, the replaceable filter element including:

a ring of filter media defining an open interior;

a first end cap secured to a first end of the filter media, the first end cap defining a flow path fluidly communicating the open interior with an exterior of the replaceable filter element, the exterior of the replaceable filter element being within the housing;

a bypass valve having:

a valve member movable between a closed position preventing fluid flow through the flow path from the exterior to the open interior and an open position permitting fluid flow through the flow path from the exterior to the open interior;

a biasing member biasing the valve member toward the closed position; and wherein:

the filter base includes an inner support with a spring biased valve member therein that remains with the filter base when the replaceable filter element is removed from the housing;

the replaceable filter element includes an imperforate section operably mounted over the inner support to deactivate the spring-biased valve thereof; and

the bypass valve does not interact with the spring biased valve member when operably mounted over the inner support.

2. The filter assembly of claim **1**, wherein the bypass valve operates entirely free of interaction with the filter base.

3. The filter assembly of claim **1**, wherein:

the first end cap includes a first portion spaced apart from a second portion, the valve member being interposed between the first portion and the second portion; and

the first portion is a generally annular member defining a first aperture communicating with the open interior and the second portion includes a second aperture, the flow

path operably communicating the first and second apertures when the bypass valve is in the open position.

4. The filter assembly of claim **3**, wherein a free end of the inner support extends through the first aperture.

5. The filter assembly of claim **4**, wherein:

the spring biased valve member is in the free end of the inner support and is axially exposed;

the second portion has a continuous central portion including the imperforate section, forming no part of the bypass valve, that extends across the first aperture and the free end of the inner support rendering the spring biased valve member of the inner support inoperable for providing fluid bypass.

6. The filter assembly of claim **1**, wherein the bypass valve is entirely radially spaced from spring biased valve member such that there is no radial overlap.

7. The filter assembly of claim **6**, wherein at least a portion of the bypass valve axially overlaps with the spring biased valve member.

8. The filter assembly of claim **1**, further comprising a second end cap secured to a second end of the filter media, the second end cap including a third aperture, the inner support extending through the third aperture.

9. A replaceable filter element comprising:

an annular ring of filter media defining an open interior;

a first end cap secured to a first end of the filter media, the first end cap defining a central axis and a flow path fluidly communicating the open interior with an exterior of the replaceable filter element;

a complete bypass valve having:

a valve member movable between a closed position preventing fluid flow through the flow path from the exterior to the open interior and an open position permitting fluid flow through the flow path from the exterior to the open interior;

a biasing member biasing the valve member toward the closed position;

wherein the first end cap includes a first portion spaced apart from a second portion, the valve member being interposed between the first portion and the second portion;

wherein the biasing member is operably interposed between the valve member and the first portion of the end cap such that the biasing member biases the valve member toward the second portion;

wherein the first portion is a generally annular member defining a coaxial first aperture communicating with the open interior and the second portion includes a second aperture laterally spaced from the central axis, the flow path being defined between the first and second apertures;

wherein the first end cap is an assembly of parts with the first portion being attached to the second portion;

wherein the first end cap includes an annular sidewall axially connecting the first and second portions, the annular sidewall preventing fluid bypass between the first and second portions; and

wherein the annular sidewall is formed with the second portion as a continuous single piece, and wherein the first portion includes an axially extending inner annular sidewall extending axially from an annular portion, the first portion being received axially within the annular sidewall, the inner annular sidewall, the annular portion and the annular sidewall forming a well receiving the first end of the filter media.

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